



STUDY THE BASIC PROPERTIES OF BITUMEN FROM HOT MIX PLANT

Sachin Rajendra Ingle

M.E., Structure, COET, Akola, Maharashtra, India.

ABSTRACT

The rapid growth of cities in recent years resulted in a lot of transportation. Road surface have experienced a significant increase of traffic flows and carrying loads. In tropical countries, the normal temperature in summer time will make the asphalt material become softer. This will also reduce the service life of the road. In India, most of highway networks made from asphalt concrete are easily damaged due to hot climate. So it is very important to study the properties on bitumen, asphalt & tar in order to make a good quality road. Following are some basics related to bitumen, asphalt & tar.

Bitumen: -Crude petroleum obtained from different places are quite different in their composition. Bitumen is an oil based substance. It is semi-solid hydrocarbon product produced by removing the lighter fraction. (such as liquid petroleum gas petrol & diesel) from heavy crude oil during the refining process. It is known as refined bitumen

Asphalt:-Asphalt is a mixture of aggregates, binder and filler used for construction and maintaining all kind of roads, parking areas but also play and sport areas.

Aggregate used for asphalt mixture could be crushed rock, sand, gravel or slag. In order to bind the aggregate into a cohesive mixture a binder is used.

Tar: -Tar is a black mixture of hydrocarbons and free carbon obtain from wide variety of organic material through distractive distillation. tar can be produced from coal, wood, petroleum, or peat. Out of the above mentioned types of materials we are going to study the properties of bitumen only.

Keywords: Bitumen, Asphalt, Tar, Penetration value, Ductility, Softening point, Specific gravity, Flash point, fire point,

CHAPTER 1 INTRODUCTION

Production of Bitumen:

Bitumen is the residue or by-product when the crude petroleum is refined. A wide variety of refinery processes, such as the straight distillation process, solvent extraction process etc. may be used to produce bitumen of different consistency and other desirable properties. Depending on the sources and characteristics of the crude oils and on the properties of bitumen required, more than one processing method may be employed.

Requirements of Bitumen:

The desirable properties of bitumen depend on the mix type and construction. In general, they should possess following desirable properties.

- ❖ The bitumen should not be highly temperature susceptible: during the hottest weather the mix should not become too soft or unstable, and during cold weather the mix should not become too brittle causing cracks.
- ❖ The viscosity of the bitumen at the time of mixing and compaction should be adequate. This can be achieved by use of cutbacks or emulsions of suitable grades or by heating the bitumen and aggregates prior to mixing.
- ❖ There should be adequate adhesion between the bitumen and aggregates used in the mix.

CHAPTER 2 METHODOLOGY

There are a number of tests to assess the properties of bituminous materials. The

following tests are usually conducted to evaluate properties of bituminous materials.

1. Penetration test
2. Ductility test
3. Softening point test
4. Specific gravity test
5. Flash and Fire point test

In this project, we are going to study the basic properties of bitumen obtained from yewada hot mix plant pune.

CHAPTER 3

TESTS ON BITUMEN

1. PENETRATION TEST

1.1 THEORY:

Penetration value is a measure of hardness or consistency of bituminous material. It is the vertical distance traversed or penetrated by the point of a standard needle in to the bituminous material under specific conditions of load, time and temperature. This distance is measured in one tenths of a millimetre. This test is used for evaluating consistency of bitumen. It is not regarded as suitable for use in connection with the testing of road tar because of the high surface tension exhibited by these materials.

1.2 OBJECTIVE:

- ❖ To determine the consistency of bituminous material.
- ❖ To assess the suitability of bitumen for use under different climatic conditions and various types of construction.

1.3 APPARATUS

- ❖ Container: A flat bottomed cylindrical metallic dish 55 mm in diameter and 35 mm in depth is required. If the penetration is of the order of 225 or more, dish of 70mm diameter and 45mm depth is required.
- ❖ Needle: A straight, highly polished, cylindrical hard steel rod.
- ❖ Water bath: Water bath maintained at $25^{\circ} \pm 0.1^{\circ} \text{C}$, containing not less than 10 litres of water, the sample being immersed to a depth not less than 100 mm from top & supported on perforated shelf not less than 50 mm from bottom of the bath.
- ❖ Transfer dish or tray: Should provide support to the container & should not rock it. It should be of such capacity as

to completely immerse container during test.

- ❖ Penetration apparatus: Should be such that it allows needle to penetrate without much friction & is accurately calibrated to give results in one tenth of a millimeter.
- ❖ Thermometer: Range $0-44^{\circ} \text{C}$ and in readable upto 0.20°C .

1.4 PROCEDURE:

- ❖ Preparation of test specimen: Soften the material to a pouring consistency at a temperature not more than 60°C for tars and 90°C for bitumen above the approximate softening point and stir it thoroughly until it is homogeneous and is free from air bubbles and water. Pour the melt into the container to a depth at least
- ❖ 10mm in excess of the expected penetration. Protect the sample from dust and allow it to cool in an atmosphere at a temperature between 15° to 30°C for one hour. Then place it along with the transfer dish in the water bath at $25^{\circ} \pm 0.1^{\circ} \text{C}$, unless otherwise stated.
- ❖ Fill the transfer dish with water from the water bath to depth sufficient to cover the container completely, place the sample in it and put it upon the stand of the penetration apparatus.
- ❖ Clean the needle with benzene, dry it and load with the weight. The total moving load required is 100 ± 0.25 gms, including the weight of the needle, carrier and super-imposed weights.
- ❖ Adjust the needle to make contact with the surface of the sample. This may be done by placing the needle point in contact with its image reflected by the surface of the bituminous material.
- ❖ Make the pointer of the dial to read zero or note the initial dial reading.
- ❖ Release the needle for exactly five seconds.
- ❖ Adjust the penetration machine to measure the distance penetrated.
- ❖ Make at least 3 readings at points on the surface of the sample not less than 10 mm apart and not less than 10mm from the side of the dish. After each test

return the sample and transfer dish to the water bath and wash the needle clean with benzene and dry it. In case of material of penetration greater than 225, three determinations on each of the two identical test specimens using a separate needle for each determination should be made, leaving the needle in the sample on completion of each determination to avoid disturbance of the specimen.

1.5 PRECAUTIONS:

- ❖ There should be no movement of the container while needle penetrates into sample.
- ❖ The sample should be free from any extraneous matter.
- ❖ The needle should be cleaned with benzene and dried before penetration.

1.6 OBSERVATIONS:

Actual test temperature = 25°C

Penetration dial reading	Test 1	Test 2	Test 3
(a) Initial	0	0	0
(b) Final	63	60	65

Mean Penetration Value = 62.66.

Therefore, the grade of bitumen is 60/70.

RECOMMENDED VALUE:

Penetration test is a commonly adopted test on bitumen to grade the material in terms of its hardness. A 80/100 grade bitumen indicates that its penetration value lies between 80 & 100. Grading of bitumen helps to assess its suitability in different climatic conditions and types of construction. For bituminous macadam and penetration macadam, IRC suggests bitumen grades 30/40, 60/70, 80/100. In warmer regions, lower penetration grades are preferred to avoid softening whereas higher penetration grades like 180/200 are used in colder regions to prevent the occurrence of excessive brittleness. High penetration grade is used in spray application works.

1.7 RESULT:

From the recommended value and the value obtained from sample, we can say that the penetration for give sample is 62.66 and hence the grade of bitumen is 60/70.

2. DUCTILITY TEST

2.1 OBJECTIVE

For determination of ductility of distillation residue, a given bitumen.

2.2 THEORY

Ductility is the property of bitumen that permits it to undergo great deformation or elongation. Ductility is defined as the distance in cm, to which a standard sample or briquette of the material will be elongated without breaking.

2.3 APPARATUS

- ❖ Briquette mould: To fill the hot bitumen.
- ❖ Ductility machine with water bath and a pulling device: To apply the tensile force on bitumen.
- ❖ Thermometer: to measure the temperature of water when it is being heated.

2.4 PROCEDURE

- ❖ The bitumen sample is method to a pouring temperature (75°C to 100°C) and poured into the mould assembly and placed on a brass plate, where a solution of glycerine or soap solution is applied at all surfaces of briquette mould exposed to bitumen.
- ❖ After the sample is poured to the mould, thirty to forty minutes the entire assembly is placed in a water bath at 27°C.
- ❖ Then the sample is removed from the water bath maintained at 27°C and excess bitumen material is cut off by levelling the surface using hot knife.
- ❖ After trimming the specimen, the mould assembly containing sample is replaced in water bath maintained at 27°C for 85 to 95 minutes. Then the sides of mould are removed and the clips are carefully booked on the machine without causing any initial strain. Two or more specimens may be prepared in the moulds and clipped to the machine so as to conduct these test simultaneously.
- ❖ The pointer is set to read zero. The machine is started and the two clips are thus pulled apart horizontally.
- ❖ While the test is in operation, it is checked whether the sample is immersed in water at depth of at least 10 mm.

2.5 PRECAUTIONS

- ❖ Use hand gloves while removing containers from oven after switching off the oven.

- ❖ Carefully fill the mould avoid air pocket with right arrangement.
- ❖ Use glycerine for easily remove bitumen from the container.

2.6 OBSERVATION

Observation for Ductility test

- (i) Bitumen grade = 60
- (ii) Pouring temperature = 175°C
- (iii) Test temperature = 27°C
- (iv) Period of cooling in minutes = 24 hrs.

OBSERVATION	1	2	3	Average value
Initial reading	00	00	00	00
Final reading	80 cm	84 cm	82 cm	82 cm

2.7 RESULTS

The ductility for give sample is 82 cm.

3. SOFTENING POINT

3.1 OBJECTIVE

Softening point denotes the temperature at which the bitumen attains a particular degree of softening under the specifications of test.

3.2 THEORY

- ❖ Softening point is the temperature at which the bituminous binders have an equal viscosity (i.e. the consistency of all the grades will be same at the softening point e.g. if two samples have softening points of 40 °C and 80 °C respectively, both will have the same consistency at their softening point.).
- ❖ The test gives an idea of the temperature at which the bituminous materials attain a certain viscosity.
- ❖ Bitumen with higher softening point may be preferred in warmer places.
- ❖ Softening point should be higher than the hottest day temperature, which is anticipated in that area otherwise bitumen may sufficiently soften and result in bleeding.

3.3 APPARATUS

- ❖ Ring — A brass shouldered ring.
- ❖ Ball— A steel ball, 9.53 mm (3/8”) in diameter, weighing between 3.45 and 3.55 grams.

- ❖ Ball centring Guide — A guide for centring the ball and made of brass.
- ❖ Ring Holder — The rings shall be supported on a brass ring holder.
- ❖ Rings shall be supported in a horizontal position with the bottoms of the rings 25 mm above the upper surface of the bottom plate and a distance of at least 13 mm and not more than 19 mm between the bottom plate and the bottom of the bath.
- ❖ The thermometer shall be suspended so that the bottom of the bulb is level with the bottom of the rings and within 13 mm of the rings but not touching them.
- ❖ Brass Pouring Plate — A flat, smooth brass plate approximately 75 by 50 mm that has been treated to prevent the bituminous material from adhering to it. A suitable treatment is to coat the plate just before use with a thin layer of a mixture of glycerine and dextrin, talc, or china clay.
- ❖ Bath — A glass vessel, capable of being heated, not less than 85 mm in diameter and not less than 120 mm in depth from the bottom of the flare.
- ❖ Thermometers — having a range from -2 to +80°C.

3.4 PROCEDURE

- ❖ FOR MATERIALS HAVING SOFTENING POINTS 80°C.
- ❖ Assemble the apparatus with the rings, ASTM Thermometer 15 °C or I5 °F, and ball centring guides in position and fill the bath with freshly boiled water to a depth of not less than 102mm and not more than 108mm. Maintain the bath temperature at 5 ± 1°C for 15 min, placing the test container in ice water if necessary. Using forceps, place a ball, previously adjusted to the bath temperature, in each ball-centring guide.
- ❖ Apply heat in such a manner that the temperature of the liquid is raised 5°C/min. Avoid the effect of drafts, using shields if necessary. (Rigid adherence to the prescribed rate of heating is absolutely essential for reproducibility of results. Either a gas burner or electric heater may be used;

however, the latter must be of the low-lag, variable output type to maintain the necessary rate of heating.)

- ❖ The rate of rise of temperature shall be uniform and shall not be averaged over the period of the test. The maximum permissible variation of any 1-mm period after the first 3 mm shall be $\pm 0.5^{\circ}\text{C}$. Reject all tests in which the rate of rise does not fall within these limits.
- ❖ Record for each ring and ball the temperature shown by the thermometer at the instant the specimen surrounding the ball touches the bottom plate. Make no correction for the emergent stem of the thermometer. If the difference between the values obtained in the duplicate determinations exceeds 1°C repeat the test.

3.5 PRECAUTIONS

- ❖ The stirrer shall be so placed that the moulds are not disturbed when the stirrer is in operation.
- ❖ The prescribed rate of heating shall be rigidly adhered to for ensuring accuracy of results.
- ❖ The rate of temperature rise shall not be

	Reading 1 in $^{\circ}\text{C}$	Reading 2 in $^{\circ}\text{C}$	Reading 3 in $^{\circ}\text{C}$	Mean value in degree
Temperature at which bitumen soften and touches the bottom plate by sinking of ball	65	67	69	67

averaged over the period of the test.

3.6 OBSERVATION

3.7 RESULTS

The Softening point for given sample is 67 $^{\circ}\text{C}$.

4 SPECIFIC GRAVITY

4.1 OBJECTIVE

This test is done to determine the specific gravity of bitumen

The objective is the ratio of mass of a given volume of bitumen to the mass of an equal

volume of water, both taken at a recorded/specified temperature.

4.2 THEORY

- ❖ Specific gravity of a bitumen binder is a fundamental property frequently required as an aid in classing binders for use in paving jobs.
- ❖ Bitumen weights sometimes have to be converted into volumes for asphalt concrete mix design calculations for which a knowledge of specific gravity is essential.
- ❖ Specific gravity is also used in identifying the source of bitumen binder.
- ❖ Bitumen binder has specific gravity in the range of 0.97 to 1.02.
- ❖ In case bitumen contains mineral impurities the specific gravity will be higher.

4.3 APPARATUS

- ❖ **Pycnometer** — glass, consisting of a cylindrical or conical vessel carefully ground to receive an accurately fitting glass stopper. The stopper shall be provided with a hole, centrally located in reference to the vertical axis.
- ❖ **Balance** — a balance conforming to the requirements of the material with pycnometer bottle.
- ❖ **Distilled water** — freshly boiled and cooled distilled water shall be used to fill the Pycnometer and the beaker.

4.4 PROCEDURE

- ❖ Clean, dry and weigh the specific gravity bottle along with the stopper (WEIGHT “A”)
- ❖ Fill the specific gravity bottle with freshly boiled distilled water and insert the stopper firmly. Keep it in the water bath having a temperature of $27.0 \pm 1^{\circ}\text{C}$ for not less than half an hour and weigh it (WEIGHT “B”)
- ❖ Weigh the specific gravity bottle about half-filled with the material (WEIGHT “C”)
- ❖ Weigh the specific gravity bottle about half-filled with the material and the other half with distilled water (WEIGHT “D”)

- ❖ Weigh the specific gravity bottle completely filled with the material (WEIGHT “E”).

4.5 PRECAUTIONS

- ❖ It is necessary that all precautions are taken in making the specific gravity bottles thoroughly cleaned and dried in the first weighting.

4.6 OBSERVATION

SR.NO.	WEIGHT				SPECIFIC GRAVITY= (C-A) / (B-A)-(D-C)	AVERAGE
	PYCNOMETER BOTTLE (A)	PYCNOMETER BOTTLE + WATER(B)	PYCNOMETER BOTTLE + BITUMEN(C)	PYCNOMETER BOTTLE + WATER+ BITUMEN(D)		
	IN (gm)	IN (gm)	IN (gm)	IN (gm)		
1	667.7	1644.0	835.0	1663.0	1.128	1.042
2	667.7	1644.0	840.0	1670.0	0.960	
3	667.7	1644.0	830.0	1650.0	1.038	

4.7 RESULTS

The specific gravity for given sample is 1.042.

5 FLASH AND FIRE POINT

5.1 OBJECTIVE

Properties of bitumen as a binding material
Grades of bitumen adapted for construction
Temperature at which bitumen catches fire due to volatiles present in bitumen.

5.2 THEORY

At high temperatures depending upon the grades of bitumen materials leave out volatiles. And these volatiles catch fire which is very hazardous and therefore it is essential to qualify this temperature for each bitumen grade.

Flash point is defined as the ash point as the temperature at which the vapour of bitumen momentarily catches fire in the form of ash under specified test conditions. The fire point is defined as the lowest temperature under specified test conditions at which the bituminous material gets ignited and burns.

5.3 APPARATUS

- ❖ **Cleveland Cup Apparatus:** It consists of test cup, heating plate, test flame applicator, heater, thermometer support and heating plate support, all conforming to the following requirements.

- ❖ The surface of the specific gravity bottle should be cleaned dry after filling with water, before weighing.
- ❖ The test temperature should be firmly adhered to.
- ❖ Inaccurate balance would never give reproducible results.

- ❖ **Test Cup** — It is made of brass. The cup may be equipped with a handle.
- ❖ **Heating Plate** — A brass, cast iron, wrought iron, or steel plate with a center hole surrounded by an area of plane depression, and a sheet of hard asbestos board which covers the metal plate except over the area of plane depression in which the test cup is supported. The metal plate may be square instead of round and have suitable extension for mounting the test flame applicator device and the thermometer support. The metal bead is mounted on the plate so that it extends through and slightly above a small hole in the asbestos board.
- ❖ All parts of cup are cleaned and dried thoroughly. Material is filled into cup upto filling mark. Lid is placed to close the cup in a closed system. All accessories including thermometer of specified range are suitably fixed. Bitumen sample is then heated. Stirring is done at regular intervals. The test flame is lit and applied at intervals depending upon expected flash and fire point. First application is made at about 17°C below actual flash point and then at every 1°C. Stirring is discontinued during the application of the test flame.
- ❖ **Test Flame Applicator** — The device for applying the test flame may be of

any suitable design, but the tip shall be 1.6 to 5.0 mm in diameter at the end and the orifice shall have an approximate diameter of 0.8 mm. The device for applying the test flame shall be so mounted to permit automatic duplication of the sweep of the test flame, the radius of swing being not less than 150 mm and the center of the orifice moving in a plane not more than 2.5 mm above the cup. A bead having a diameter of 3.8 to 5.4 mm may be mounted in a convenient position on the apparatus so the size of the test flame can be compared to it.

- ❖ **Heater** — Heat may be supplied from any convenient source. The use of a gas burner or alcohol lamp is permitted, but under no circumstances are products of combustion or free flame to be allowed to come up around the cup. An electric heater controlled by a variable voltage transformer is preferred. The source of heat shall be centered under the opening of the heating plate with no local superheating.
- ❖ **Thermometer Support** — A device which will hold the thermometer in the specified position during a test and permits easy removal of the thermometer from the test cup upon completion of a test.
- ❖ **1. Heating Plate Support** — Any convenient support which will hold the heating plate level and steady may be employed.
- ❖ **2. Shield:** A shield having an area of 460mm² and 610mm high and having an open front is used.
- ❖ **3. Thermometer:** A thermometer having the required range

5.4 PRECAUTIONS

- ❖ Do not breathe close to the apparatus as the fumes are injurious to health.
- ❖ Turn the fans off so that the fumes can be accumulated over the cup.
- ❖ Tip of the thermometer should not touch the bottom or sides of the cup.
- ❖ The operator must exercise and take appropriate safety precautions during the initial application of the test flame, since samples containing low flash material

may give an abnormally strong flash when the test flame is first applied.

5.5 OBSERVATION

Test	Trial value of temperature in C			Average value
	1	2	3	
Flash point (C)	170	180	175	175
Fire point (C)	200	208	204	204

5.6 RESULTS

The flash point for given sample is 175 °C.

Also fire point for given sample is 204°C.

CHAPTER 3

CONCLUSION:

From the above test we can conclude that:

- ❖ The grade of bitumen is 60/70 which is suitable for the road construction as Grading of bitumen helps to assess its suitability in different climatic conditions and types of construction.
- ❖ The ductility of bitumen is 82 cm which tells us about the tensile strength of bitumen.
- ❖ The softening point of bitumen is 67 °C just to know the temperature up to which a bituminous binder should be heated for various road use applications.
- ❖ The specific gravity for given sample is 1.042. Bitumen binder has specific gravity in the range of 0.97 to 1.02. thus in case bitumen contains mineral impurities the specific gravity will be higher. Which indicates that the bitumen is impure and the impurities need to be removed to obtain good quality bitumen.

CHAPTER 4

REFERENCES:

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2. IS: 208-1978. Ductility test
3. IS: 1205 – 1978. Softening point test
4. IS 1202-1978 Specific gravity test
5. IS 1209-1978 Flash and Fire point test